PATENT SPECIFICATION

DRAWINGS ATTACHED

1014081

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Int. Cl.:—B 23 g//F 06 d

COMPLETE SPECIFICATION

Power Operated Rotary Impact Tool

I, SPENCER BENNETT MAURER, a citizen of the United States of America, residing at County Line Road, Novelty, Ohio, United States of America, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a power operated rotary impact tool wherein unlimited rotation of the drive member in one direction is effected by limited oscillatory rotation of the motor, and more specifically to a rotary impact tool, such as a wrench, wherein a hammer is oscillated with respect to an anvil and the impact surface of the hammer and anvil are always in the same path of rotation.

An example of a known type of tool is given in my United States Patent Specification No. 2898791.

In the tool shown in that specification there is an inside rotor member coupled to a separate hammer member, and there is an outside reaction member coupled loosely to the anvil member, and connected to the housing by means of an over-running clutch. All of the reaction torque from the reaction member is transmitted to the tool housing.

According to the present invention, there is provided a rotary impact tool comprising a housing, a motor and an output drive member, said motor comprising a reaction member and a rotor, said rotor including a hammer for driving an anvil portion of said output drive member, said rotor surrounding a part of, and being capable of limited rotary motion relative to, said reaction member, said rotor and said reaction member being both rotatable relative to said housing, said output drive member being connected to said reaction member by means of a lost motion device, wherein unlimited rotation of the drive member is effected by limited oscillatory rotation of the motor in operation and the impact surfaces of the hammer and anvil are always in the same path of rotation.

In a preferred tool according to the present invention the reaction member is the central shaft while the surrounding motor parts constitute the combined rotor-hammer assembly. The reaction shaft is connected to the tool housing by means of an overrunning clutch somewhat similar to that in the tool shown in the above specification. Also, the reaction shaft is loosely coupled to the anvil similar to the tool of the U.S. patent specification No. 2898791, and the over-running roller clutch transmits all of the reaction torque from the reaction shaft of the tool housing.

The invention will now be described by way of example with reference to the accompanying drawings, wherein:—

Figure 1 is a longitudinal section through the centre of a tool embodying the invention.

Figure 2 is an exploded view of the parts of the tool with the housing removed.

Figure 3 is a view of a portion of the tool from another direction.

Figure 4 is a rear view of the tool.

Figures 5—A, B, C and D are sections through the tool along lines A—A, B—B, C—C, and D—D of Figure 1, showing the correct relationship of the parts at impact in a forward direction.

Figures 6—A, B, and C show the conditions an instant after impact when the hammer has retracted more than half way.

Figures 7—A, B, and C show the conditions at a later point in the rotary cycle.

Figures 8—A, B, and C show the parts as the hammer approaches the jaw to strike another blow.

Figures 9—A, B, C and D show the sections at impact in the reverse direction.

The embodiment comprises a rotary power device, for use as an impact wrench or the like, which preferably is pneumatically driven, and wherein there is a housing with output

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shaft means including impact receiving surface means mounted in the housing for rotation with respect thereto. A motor reaction member means is mounted within the housing for rotation with respect thereto, and is coupled to the output shaft with slight lost motion. Together the reaction member means and the output shaft may be called the central shaft reaction member means.

Clutch means including an overload slip clutch connect the reaction member means to the housing to allow unrestrained motion of the reaction member means in the direction of operation of the tool and to apply a limited restraining torque to its motion in the opposite direction. Massive rotor means are provided, including impact delivering surface means, mounted for rotation within the housing. Motor means apply torque to the rotor means and to the reaction member means to establish limited rotation therebetween in either direction. Automatic reversing means including rotary position valve means is associated with the reaction member means and the massive rotor means to periodically reverse the direction of the motor torque to cause the rotor means to oscillate relative to the reaction member means so that as the rotor means approaches either extreme of relative oscillation the motor torque reverses so as to oppose further approach. The above rotary position valve means includes biasing means so that, for forward operation of the tool, the impact delivering jaw more closely approaches the impact receiving jaw in a forward direction than in the reverse direction before the motor torque reversal occurs, to deliver an impact blow in the forward direction.

Manual reversing means are provided to control the direction of operation of the tool and include means to reverse the above mentioned biasing means and the direction of free motion of the above mentioned overrunning clutch.

In the drawings an output or anvil shaft 115 extend through the forward end of a housing 116 and is journaled there in a bushing 117. A reaction shaft 118 is journaled on its forward end in the anvil shaft 115 and is adapted for limited rotary motion of approximately 80° relative to the anvil shaft 115 by a locking or drive pin 75 engaging a flat surface 76 on the reaction shaft 118. The reaction shaft 118 is supported at the other end by a rear bushing 119 and a ball bearing 120. A rotor assembly comprises a rear end plate 121, a cylinder 122, a front end plate 123, and a hammer 124, all rigidly bolted together by bolts 114 to act as a massive hammer element. This assembly is supported on the reaction shaft 118 by a ball bearing 125 mounted in the rear end plate 121 and by needle bearing 126 mounted in the hammer 124. A bearing sleeve 127 is keyed to the reaction shaft 118 and includes a driving lug 128 which operates an exhaust valve plate 129 with a lost motion cam action.

The hammer 124 includes an impact delivering jaw 130, and the anvil shaft 115 includes an impact receiving jaw 131. These jaws always lie in the same path of rotation and permit approximately 220° of relative motion. The rotor assembly surrounds a central portion 132 of the reaction shaft 118 forming an annular motor cavity which is divided into two pressure-tight portions 167, 168 by the longitudinal rotor vanes 136 and 137. The rotor vane 136 is mounted in a shoe 133 riveted to the inside of cylinder 122 and slidingly contacts the outside of reaction shaft 118. Shaft vane 137 is mounted in a slot 135 in the reaction shaft 188 and slidingly contacts the bore of cylinder 122. The end plates 121 and 123 sealingly contact the ends of the vanes 136 and 137, the ends of the cylinder 122 and the central portion 132 of the reaction shaft 118 to define the two motor chambers 167 and 168. Maximum relative rotary motion of the motor parts is approximately 300° from one extreme to the other. The front end plate 123 has extending through it two exhaust holes 170, 171, approximately equidistant angularly from the rotor vane 136 which cooperate with exhaust valve plate 129 to form the exhaust valve.

The reaction shaft 118 is keyed to a hub 140 by means of a square connection 141. A rubber member 142 has a tight frictional fit on the O.D. hub 140 and on the I.D. of a clutch sleeve 143 to form an overload slip clutch in the drive connection between the reaction shaft 118 and roller clutch sleeve 143. The rear portion of clutch sleeve 143 has a bore which contacts clutch roller member 144 of the roller clutch assembly. A roller cage 145 retains the clutch roller members 144 and keeps them in their proper position relative to the flats of the hexagonal section 147 on the outside of inlet bushing 119. The inlet bushing 119 is press-fitted into the back portion of the housing 116. A biasing spring 153 is mounted in a reversing lever 154 and exerts force on a button 155 which in turn biases the roller cage 145 either to the right or to the left depending on the desired direction of rotation. For forward operation of the tool, button 155 exerts a counter-clockwise torque on roller cage 145 as shown in Figure 5-D with the reversing lever 154 in the position shown in Figure 4. Thus the reaction shaft 118 through frictional engagement with clutch sleeve 143 is restrained from backward, or counter-clockwise rotation but is allowed to turn freely in a forward or clockwise direction. In this tool the overload slip clutch, comprised of hub 140, rubber 142, and clutch sleeve 143 serves only as a safety device and transmits the full motor torque to the housing.

To reverse the direction of operation of the tool, reversing lever 154 is rotated counter-

clockwise so that the spring 153 exerts a pressure through button 155 on roller cage 145 in a clockwise direction, as shown in Figure 9-D, so that reaction shaft 118 is allowed to turn freely in a reverse or counter-clockwise direction but not in the forward direction.

Air is admitted to the tool through throttle 160 to port 161 and from port 161 the air flows backwards through tubular port 162 to the rear end of the tool and then radially inward through port 163 to groove 164 in rear bushing 119. The air then flows radially inward through drilled ports 165 to the central bore 166 of the inlet bushing and axially forward through central bore 166 of reaction shaft 118 to the bottom of shaft vane 137, thence radially outward between vane 137 and the side of the slot 135 in shaft 118 into one or the other of the motor chambers 167 and 168 depending upon the position of vane 137. The vane position depends upon which of chambers 167 and 168 is vented by one or the other of exhaust ports 170, 171. In figure 5A air is being admitted to chamber 167 between vane 137 and the edge 134 of slot 135. Chamber 168 is vented to atmosphere through exhaust port 171 and holes 100 in the front housing. Exhaust port 170 is closed by plate valve 129 as shown in Figure 5-B. Pressure in chamber 167 creates a counter-clockwise torque on the rotor assembly and a clockwise torque on the reaction shaft. Pressure in chamber 168 would provide the opposite torques on these members.

The shaft van 137 acts as a remotely controlled pressure sensitive valve to divert the live air supply to whichever of the two motor chambers is best able to retain it. Since one or the other of the exhaust ports 170, 171 is always open, the live air is always diverted to the smaller of the two motor chambers when the rotor unit is approaching either extreme of its stroke relative to the reaction shaft. When the rotor is near the center of its stroke relative to the shaft (the exhaust holes 170, 171 straddle the shaft vane 137) the air may be diverted to either one of the motor chambers, depending on the position of the exhaust valve plate 129, but not to both due to the inherent instability of the inlet valve vane 137 when in a mid-position in the slot 135 of shaft 118. Thus the rotor unit tends to oscillate about its mid position relative to the reaction shaft. The inertia of the rotor unit, the lost motion between valve plate 129 and driving lug 128, and the remote operation of the inlet valve vane 137 all co-operate to insure this action regardless of the air pressure supplied.

Impact action of the rotor hammer unit 124 in one direction only on the anvil jaw 131 is obtained by causing the reaction shaft 118 to be biased in this same direction (toward this anvil jaw) an amount equal to one half the difference between the maximum possible strokes of the motor unit and of the impact jaws, by the motor torque when effective in this direction. Motion of the reaction shaft in the opposite direction under reverse motor torque is prevented by the roller clutch 144, 147.

From this it can be seen that the effective operation of this tool depends upon the maintenance of the reaction shaft in its properly biased position relative to the anvil jaw.

Every impact blow on the anvil drives the anvil forward relative to the reaction shaft in effect moving the reaction shaft out of its properly biased position. To restore the correct bias the motor torque must overcome the frictional torque of the overrunning clutch in the slip direction and move the shaft ahead again to its proper position before the rotor unit, rebounding at high velocity from the anvil and being aided by motor torque, has reached the valve shift position. Low moment of inertia of the reaction shaft and low frictional resistance of the overrunning clutch, in a slip direction, are essential to proper rebiasing and therefore to proper operation of the tool.

The design of the prior art oscillating impact wrench employs a different structure which has a massive reaction member surrounding a central shaft rotor member and a reversible spring clutch of inherently high frictional slip torque for the overrunning clutch means. The present design is a great improvement over the prior art due to the greatly reduced moment of inertia of the reaction member and the reduced friction of the overrunning roller clutch in the slip direction.

In operation, with the parts arranged as shown in Figures 5—A, B, C, and D, air is admitted to chamber 161 by depressing throttle button 160. From chamber 161 the air flows to the rear of the tool through port 162 and then radially to the center of the tool at the rear end through passage 163 to groove 164 in the rear of inlet bushing 119, thence through ports 165 to the central bore 166 of the central reaction shaft member 118. The air then flows forward to the area immediately under vane 137 which is mounted in the slot 135 in central shaft 118. The air then escapes radially outward between the vane and the sides of this slot either through clearance 134 on one side or 135 on the other side into motor chambers 167 and 168 respectively. Since chamber 168 is connected to atmosphere through exhaust hole 171 in the forward end plate 123 the pressure in this chamber does not rise appreciably while the pressure in chamber 167 which is not connected to atmosphere rises appreciably and tilts vane 137 in a clockwise direction, thus effectively sealing off the passageway 135 and exerting a clockwise torque on the central reaction shaft member. Since the reverse lever 154 is set for forward operation as shown in Figure 5-D, the roller cage 145 is being held in a counterclockwise direction by spring 153 and

button 154, allowing clutch sleeve 143 to rotate only in a clockwise direction, and since the central shaft 118 is effectively connected to this member the central shaft can rotate only in a clockwise direction. The central shaft can rotate clockwise only until the flat 76 on the forward end of the central shaft 118 comes in contact with drive pin 75 mounted in the anvil shaft 115. The forward torque on the shaft 118 is thus transferred to the anvil 115 which during forward impact operation is restrained from forward motion by the work being tightened. The shaft is thus biased in a clockwise direction relative to the anvil jaw to the limit allowed by drive pin 75. Since the roller clutch prevents backward motion of the shaft, the shaft 118 tends to remain in this position relative to the anvil jaw as long as the reverse lever is set for forward operation. Pressure in chamber 167 at the same time exerts a counterclockwise force on vane 136 which is mounted in the rotor assembly. Thus, as the rotor assembly turns in a counterclockwise direction the exhaust valve plate 129 moves up against lug 128 which causes the valve plate 129 to be shifted to the position shown in Figures 6-B. Since lug 128 is keyed to shaft 118 the timing of the shift of the valve plate is dependent upon the rotary position of the rotor assembly relative to the central shaft. The shift of the valve plate closes port 171 in the front end plate and opens port 170. Thus motor chamber 167 is vented to atmosphere and chamber 168 is sealed. The rotor assembly, however, continues to coast in a counterclockwise direction due to kinetic energy which has been stored in it until it reaches the position shown in Figure 7-A. At this time, due to compression of air in chamber 168, the pressure has increased in this chamber and due to the elapsed time the compressed air in chamber 167 has had time to escape out of exhaust port 170 so that the side pressure forces on vane 137 are now unbalanced in a counterclockwise direction causing a shift of the vane, and the passage 134 is sealed and passageway 135 is opened, thus admitting live air directly to chamber 168 further applying a counterclockwise torque on central reaction shaft member 118 and a clockwise torque on the rotor assembly. The central reaction shaft member 118 is restrained from moving in a counterclockwise direction by the rollers 144 of the roller clutch assembly. The rotor assembly, however, will continue to coast an additional amount in a counterclockwise direction until all of the kinetic energy has been absorbed and the rotor assembly is then started in a return clockwise direction. This forward or clockwise rotation of the rotor assembly continues until the exhaust port 170 is again closed and port 171 opened as the exhaust valve shifts just before the impact blow is struck as shown in Figures 8—A, and B and C. The pressure in motor chamber 167 now begins to increase due to compression as the rotor assembly continues to travel toward the impact position. The pressure in motor chamber 168 at the same time is dropping and before the impact blow is struck the valve vane 137 is again shifted to the other side of the slot so that passageway 135 is closed and passageway 134 is opened to rapidly build up pressure in motor chamber 167 thus again reversing the direction of the motor torques. Before appreciable kinetic energy is lost the impact blow is struck, driving the anvil forward (out of bias) and causing the rotor hammer assembly to rebound in a counterclockwise direction in which action it is aided by motor torque. At the same time the motor torque on the reaction member drives the shaft in a clockwise direction until flat 76 again contacts drive pin 75 in anvil 115 as the correct bias relationship is re-established and another cycle has begun.

To operate the tool in reverse the reversing lever is shifted counterclockwise and the spring biased button 155 assumes the position shown in Figure 9-D. In this position the roller cage is biased in a clockwise direction which prevents any clockwise motion of the clutch member 143 but allows counterclockwise motion. The Figures 9-A, B, and C show the arrangement of the parts just at the moment of impact in a reverse direction. The central shaft 118 as shown in Figure 9-C is biased in a counterclockwise direction relative to the anvil shaft 115 in which position it tends to remain for reverse operation. This changes the rotary relationship of the reaction shaft 118 relative to the anvil jaw 131 so that the rotor assembly oscillates relative to the rection shaft in the same fashion as before, the hammer strikes the impact blow at the other end of its stroke, thus impacting in a counterclockwise or reverse direction.

It will be realised that the number of parts of the above-described tool is kept to a minimum, resulting in relatively inexpensive manufacture.

Furthermore, the hammer and anvil jaws always lie in the same path of rotation so that the jaws are always in proper alignment for mating with each other, thereby obviating the difficulties which are prevalent in some prior art tools, namely chipping of the impact surfaces due to occasional mismating of the jaws and high wear rate of the jaws due to frictional forces as the jaws are pulled out of engagement with each other, and thereby obviating many parts which were necessary in some prior art tools to cause the disengaging motion of at least a portion of the hammer.

The above-described tool has certain advantages over that described in the above-mentioned U.S. specification No. 2,898,791.

Among them are:—

In the present tool the rotor member is the

larger outside member of the motor and includes the hammer jaw as an integral part, thus utilizing the naturally massive motor member as the hammer. Consequently, the present tool is smaller, lighter and less expensive to manufacture, yet is more powerful, efficient and durable.

A further advantage of the aforesaid reversed relationship in the masses of the motor members is a decided increase in the free rundown speed of the tool, due to the manner in which the bi-directional oscillating motor produces unidirectional rotation of the output shaft under free conditions.

The embodiment shown is much more comfortable to hold and operate since the maximum amount of reaction torque which can be applied to the handle is definitely limited to a relatively low degree by an overload slip clutch. This clutch provides sufficient resistance to backward motion of the reaction shaft relative to the housing to establish a net forward rotation of the output shaft in the desired direction under free run-down conditions. However, once the work being tightened has been seated and has attained a relatively modest degree of tightness, backward motion of the reaction shaft is prevented since it is directly coupled to the work through the output shaft. Thus the full power output is realized and the bulk of the reaction torque is taken by the work itself.

While there have been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the scope of the invention.

Reference is made to my co-pending application No. 7482/65 (Serial No. 1014082), divided out from the present application and describing and claiming a rotary impact tool comprising a housing, a motor and an output drive member, said motor comprising a reaction member and a rotor, said rotor including a hammer for driving an anvil portion of said output drive member, said rotor surrounding a part of, and being capable of limited rotary motion relative to, said reaction member, said rotor and said reaction member being both rotatable relative to said housing, wherein unlimited rotation of the drive member is effected by limited oscillatory rotation of the motor in operation and the impact surfaces of the hammer and anvil are always in the same path of rotation.

WHAT I CLAIM IS:—

1. A rotary impact tool comprising a housing, a motor and an output drive member, said motor comprising a reaction member and a rotor, said rotor including a hammer for driving an anvil portion of said output drive member, said rotor surrounding a part of, and being capable of limited rotary motion relative to, said reaction member, said rotor and said rection member being both rotatable relative to said housing, said output drive member being connected to said reaction member by means of a lost motion device, wherein unlimited rotation of the drive member is effected by limited oscillatory rotation of the motor in operation and the impact surfaces of the hammer and anvil are always in the same path of rotation.

2. A tool according to claim 1 wherein said lost motion device comprises an axially directed pin on said output drive member and a peripheral flat on said reaction member.

3. A tool according to any preceding claim including an over-running clutch between said housing and said reaction member which at any time allows rotation of said reaction member in one direction only relative to said housing.

4. A tool according to claim 3 wherein said clutch is an over-running roller clutch.

5. A tool according to claim 4 wherein said clutch has a roller cage and an inner race member which is hexagon shaped and the cage and inner race member can be biased one relative to the other so as to permit rotation selectively in one direction or the other.

6. A tool according to any of claims 3 to 5 including an overload slip clutch between said reaction member and said housing, capable of allowing rotation of the reaction member in the other direction in overload conditions.

7. A tool according to claim 6 wherein said overload slip clutch comprises a rubber ring in frictional engagement between said reaction member and the rotatable portion of said over-running clutch.

8. A tool according to any preceding claim wherein said motor comprises a first radial sealing member on said reaction member and a second radial sealing member on said rotor, which sealing members divide an annular chamber between the reaction member and the rotor into two parts such that a differential air pressure may be established between the two parts so as to drive the rotor relative to the reaction member.

9. A tool according to any preceding claim including means for reversing the direction of drive of said motor.

10. A rotary impact tool substantially as herein described with reference to the accompanying drawings.

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1014061 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

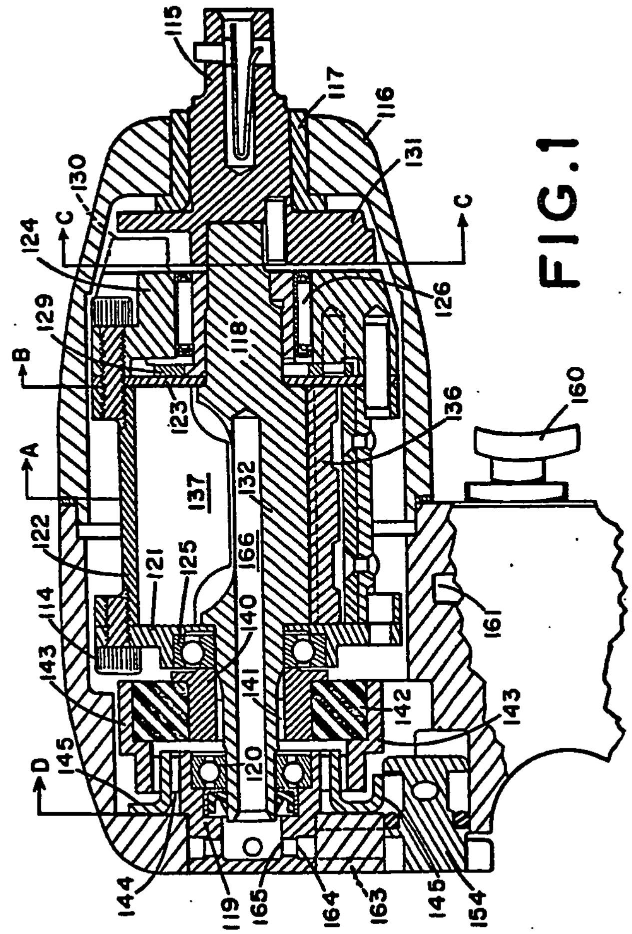


FIG. 1

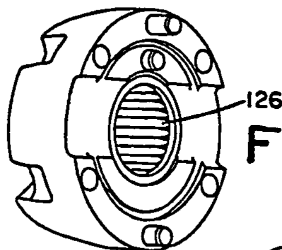


FIG.3

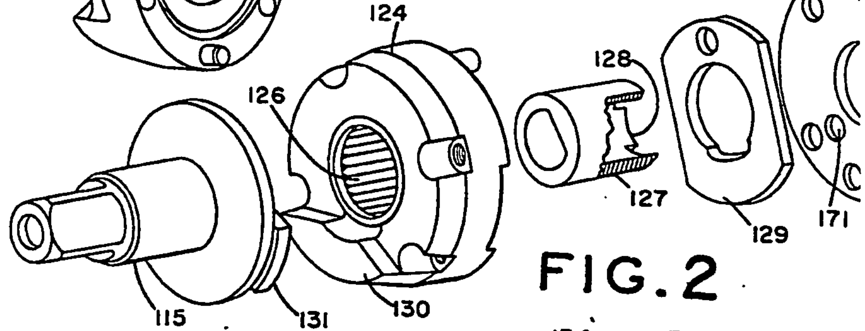


FIG.2

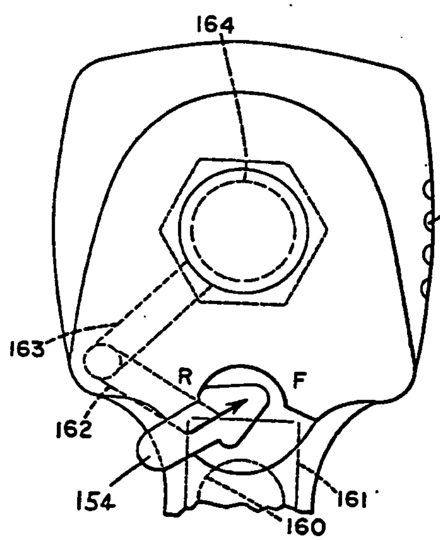


FIG.4

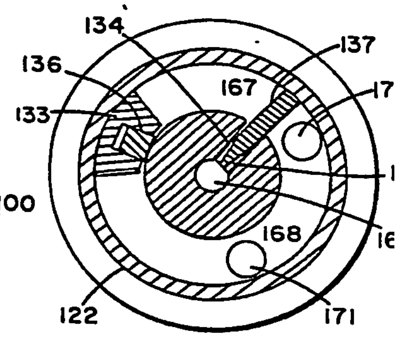
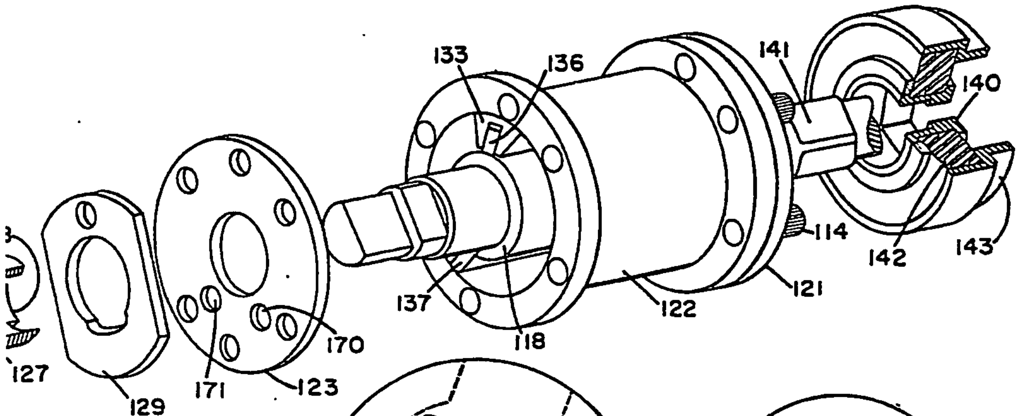
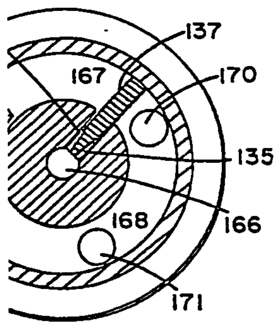


FIG. 5A



G. 2



G. 5A

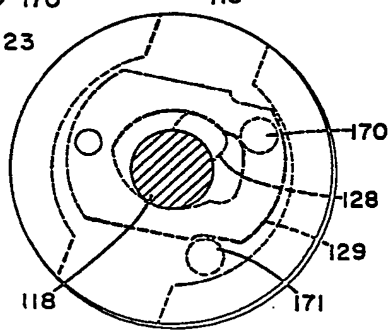


FIG. 5B

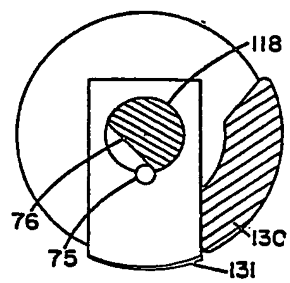


FIG. 5C

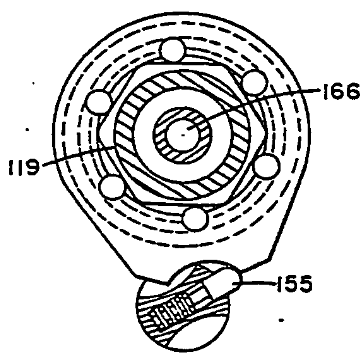


FIG. 5D

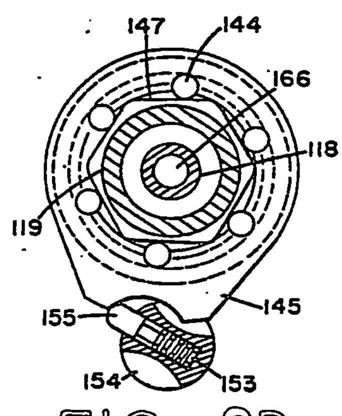


FIG. 9D

1014081 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

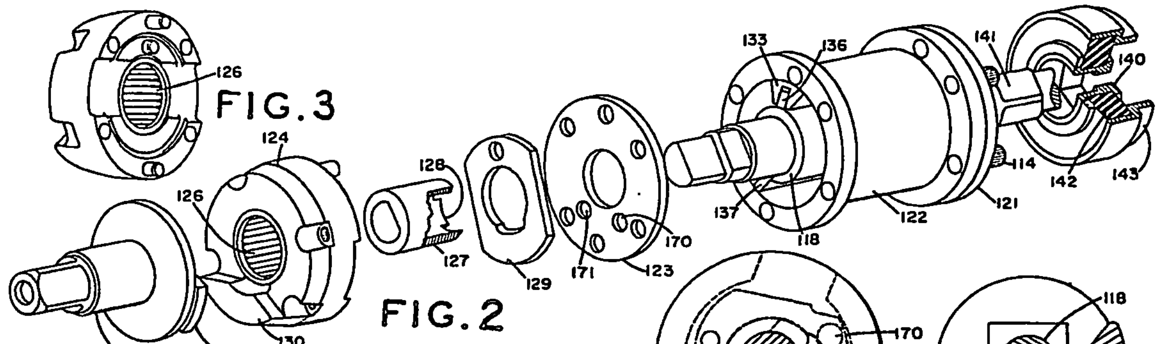


FIG.3

FIG.2

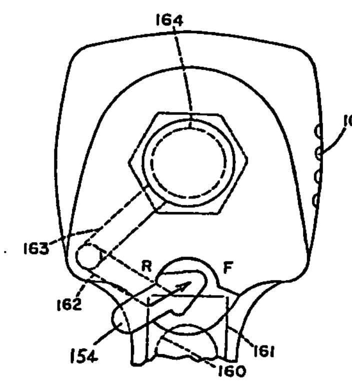


FIG.4

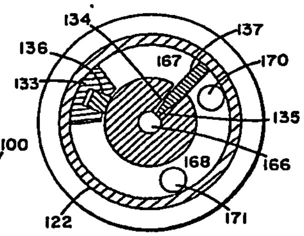


FIG. 5A

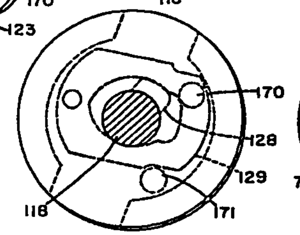


FIG. 5B

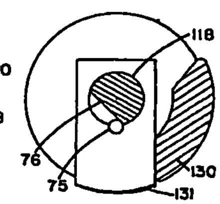


FIG. 5C

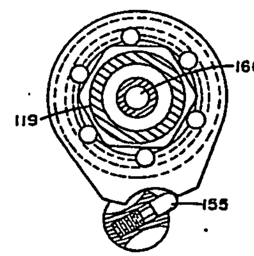


FIG. 5D

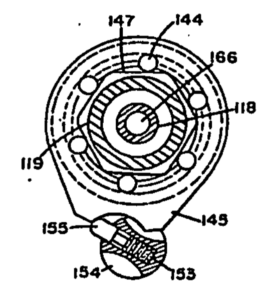


FIG. 9D

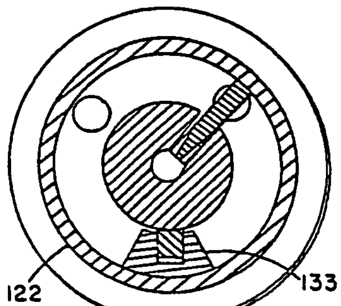


FIG. 6A

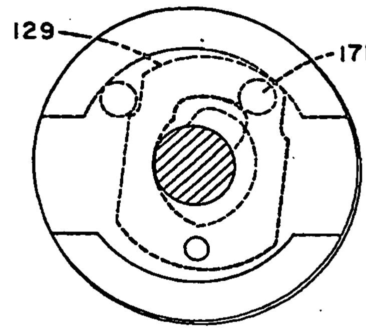


FIG. 6B

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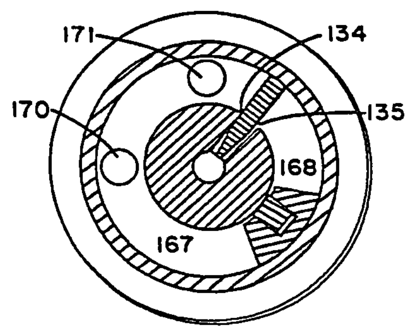


FIG. 7A

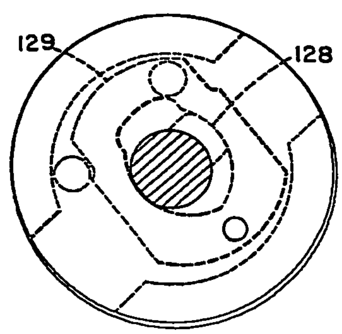


FIG. 7B

F

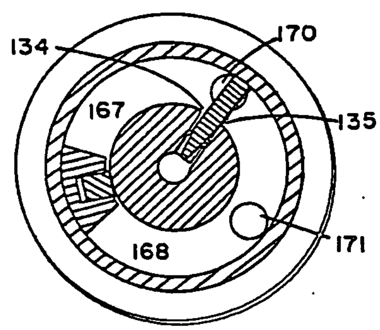


FIG. 8A

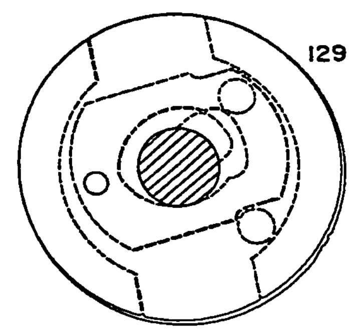
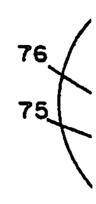
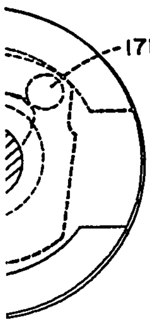


FIG. 8B



F

1014081 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3



6B

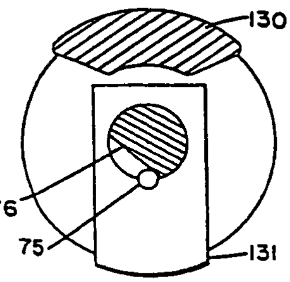


FIG. 6C

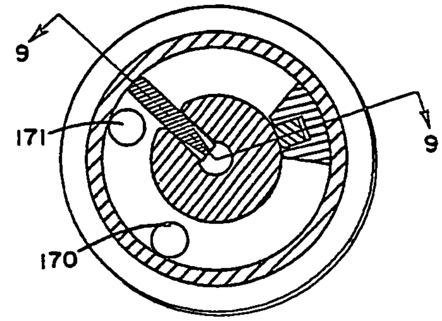
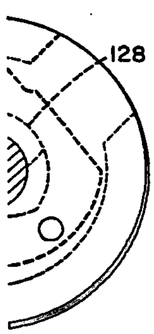


FIG. 9A



. 7B

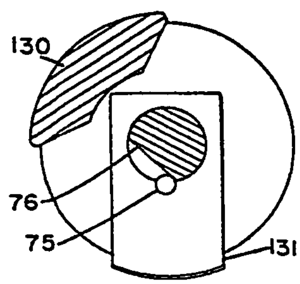


FIG. 7C

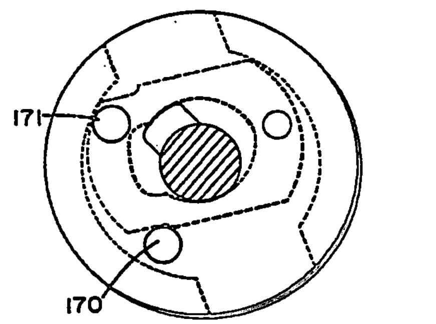
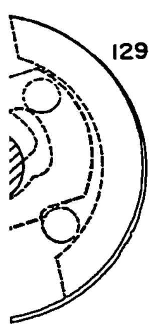


FIG. 9B



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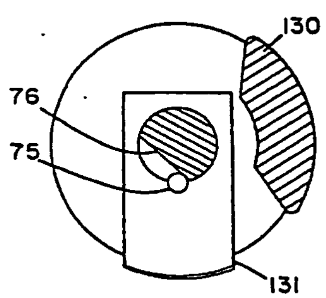

FIG. 8C

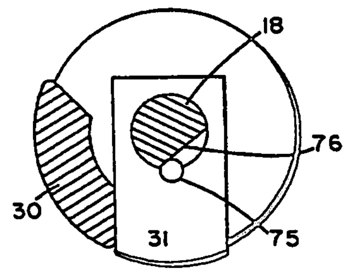

FIG. 9C

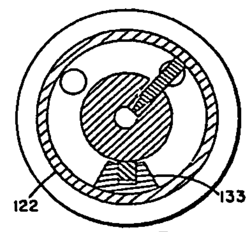

FIG. 6A

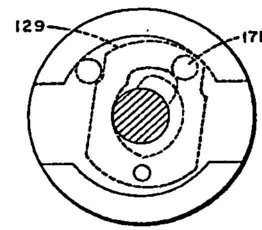

FIG. 6B

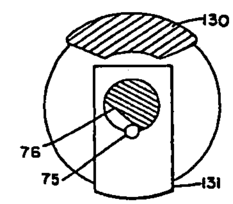

FIG. 6C

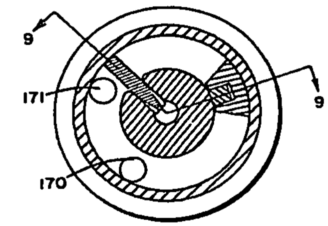

FIG. 9A

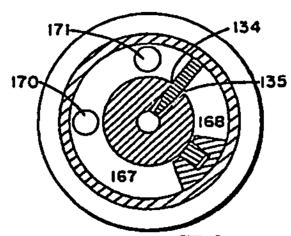

FIG. 7A

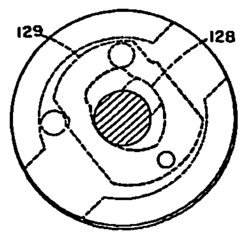

FIG. 7B

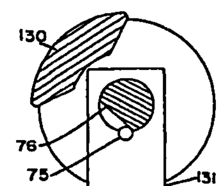

FIG. 7C

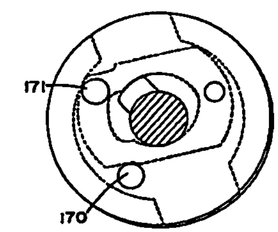

FIG. 9B

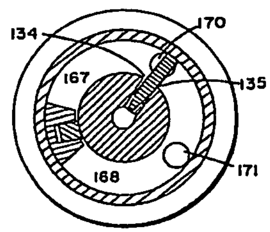

FIG. 8A

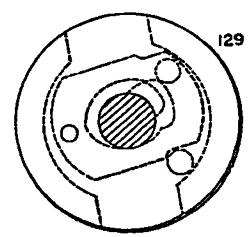

FIG. 8B

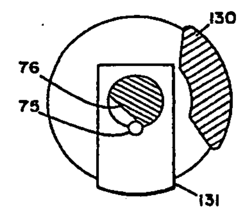

FIG. 8C

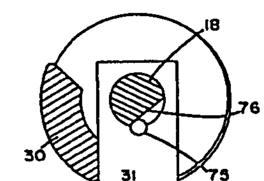

FIG. 9C